ARMY RESEARCH LABORATORY

Simulating Sympathetic Detonation of 105-mm Artillery Projectiles with CTH

by Kelly J. Benjamin
and John Starkenberg

ARL-TR-1365

June 1997

Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5066

ARL-TR-1365 **June 1997**

Simulating Sympathetic Detonation of 105-mm Artillery Projectiles with CTH

Kelly J. Benjamin, John Starkenberg
Weapons and Materials Research Directorate, ARL

Abstract

The CTH code was used to simulate sympathetic detonation experiments conducted using 105-mm projectiles separated by buffers of Plexiglas, rolled homogeneous armor (RHA), and mild steel. Buffer thicknesses near the experimental sympathetic detonation threshold were simulated. No propagation criterion associated with pressure loading was revealed by the results of this study. CTH computations were also made to confirm the presence of finite rise-time or "ramp" waves in the acceptor explosive (previously observed in Lagrangian computations) with layered buffers of Plexiglas and steel. The CTH results show more structure in the ramp wave and shorter rise times than those previously obtained. The History Variable Reactive Burn (HVRB) explosive initiation model in the CTH code was exercised in simulations of similar configurations. These simulations showed that initiation may occur during propagation of the incident shock wave through the acceptor or after its reflection from the casing at the back of the acceptor. Predicted buffer thicknesses required to prevent sympathetic detonation are much less than those determined in the experiments, indicating that mechanisms in addition to shock initiation contribute to sympathetic detonation.

TABLE OF CONTENTS

INTENTIONALLY LEFT BLANK.

LIST OF FIGURES

INTENTIONALLY LEFT BLANK.

LIST OF TABLES

INTENTIONALLY LEFT BLANK.

1. INTRODUCTION

Sympathetic detonation of munitions occurs when a detonating munition (the donor) initiates detonation in a neighboring munition (the acceptor). Shock due to casing impact is the primary propagation mechanism for unshielded munitions at close range, while at longer range, fragment penetration is the primary mechanism. Shielding (buffers) between munitions reduces the incidence of sympathetic detonation by reducing shock stimulus and impeding fragments.

The present study employed the CTH code (Hertel et al. 1993) and focused on three objectives. The first was to determine if any similarities in pressure-loading exist when using CTH to simulate buffered sympathetic detonation experiments with buffer thicknesses near the sympathetic detonation threshold, as determined in experiments. The second objective was to confirm the presence of finite rise-time or "ramp" waves in the acceptor explosive previously observed using the nonreactive Lagrangian code STEALTH (Electric Power Research Institute 1981). The third objective was to exercise a CTH reactive model within the acceptor explosive.

2. DESCRIPTION OF CTH

The continuum mechanics solver CTH is an ongoing project of the Sandia National Laboratory. It is intended to provide capabilities for modeling dynamics of multidimensional systems with multiple materials, large deformations and strong shock waves. Finite-difference analogs of the Lagrangian equations of momentum and energy conservation are employed with continuous rezoning to construct Eulerian differencing. Shock and detonation waves are treated using the method of artificial viscosity. CTH makes use of analytic (Mie-Gruneisen, JWL, etc.) and tabular (Sesame) equations of state as well as modern constitutive models (Johnson-Cook, Zerilli-Armstrong) including fracture (void insertion). In addition, there are three reaction models (Programmed Burn, CJ Volume Burn and History Variable Reactive Burn [HVRB]) and two porosity models. A variety of plots of computed results can be produced. These options provide an opportunity to treat complex material behavior including melting, vaporization, solid phase transitions, chemical reaction, and electronic excitation and ionization.

3. BRIEF DESCRIPTION OF THE EXPERIMENTS

The experimental arrangement (Boyle 1995) is illustrated in Figure 1. Both the donor and the acceptor munitions were 105-mm projectiles. In each experiment, the donor was filled with Composition B and the acceptor with pentolite. Each donor was initiated at a point on the side farthest from the acceptor, halfway between its top and bottom. Potted carbon gauges and steel witness plates were used to record the results. Buffer materials included polyethylene, mild steel, and rolled homogeneous armor (RHA). All buffers were 203 mm wide and 510 mm high. The thickness of the buffers was varied in order to determine a sympathetic detonation threshold.

The experimental results are summarized in Table 1. The "GOs" represent configurations in which sympathetic detonation of the acceptor occurred, while the "NOGOs" indicate that sympathetic detonation did not occur. Threshold ranges obtained from these results determined the buffer thicknesses we simulated computationally.

4. CTH SIMULATION OF THE EXPERIMENTS

The 2-D CTH simulation (representing the cross-sectional plane in which the donor is initiated) is illustrated in Figure 2. The primary effect of simulating a 3-D experiment in 2-D is to decrease the rate of decay of spherically divergent waves to that of cylindrically divergent waves. This produces somewhat higher stimulus levels in the 2-D case. The experiments were simulated with buffer thicknesses near the sympathetic detonation threshold for each buffer material. The dimensions were consistent with M1 105-mm projectiles. Casings were 10-mm-thick mild steel. The donor munition was filled with Composition B, modeled using a JWL equation of state for detonation products. The acceptor fill was "inert" pentolite, represented by a JWL equation of state with estimated constants. The donor munition was initiated at the side farthest from the acceptor using the programmed burn model. All buffers were 203 mm wide. Plexiglas was substituted for polyethylene, which was used as a buffer material in some of the original experiments. The buffer thicknesses were 70 mm and 76 mm for the Plexiglas buffers, 32 mm and

38 mm for the mild-steel buffers, and 38 mm and 51 mm for the RHA buffers. In addition to the threshold computations, a computation was made with a 38-mm-thick RHA buffer to enable direct comparison with the mild-steel computation at the same thickness.

Figure 3 shows a sequence of pressure contour plots for the Plexiglas buffer. The programmed burn detonation can be seen propagating across the donor munition in the first frame, while subsequent frames illustrate a shock wave propagating through the buffer and casing of the acceptor and into the acceptor explosive. The buffer is nearly obliterated and the acceptor is significantly deformed at late times. A crack can be seen in the casing at the back of the acceptor in the last frame. Figures 4 and 5 illustrate pressure and impulse history plots, respectively, from the same computation, taken at a point just inside the acceptor casing. The loading consists of an initial pulse about 40 μs wide, followed by significant late-time reverberations. The impulse history plot indicates that about half the ultimate impulse delivered is associated with the reverberations.

Figure 6 is a comparison of pressure contour plots for the Plexiglas buffer with similar plots for a mild-steel buffer. The shock arrives at the acceptor explosive 15 μs sooner in the mild-steel buffer simulation, due to the smaller thickness of and higher wave speed in the steel. Otherwise, the results from both the Plexiglas and mild-steel buffer simulations appear similar. At late times, some cracking on the front of the acceptor near the center can be observed with the steel buffer and acceptor casing, but no cracking is seen at the back of the casing. As illustrated in Figure 7, significant differences in pressure-loading are indicated in the pressure and impulse history plots. With the mild-steel buffer, the initial pulse is higher and narrower and the late-time pressures remain insignificant. Thus, though the impulse associated with the initial pulse is higher with the mild-steel buffer, the ultimate impulse is higher with the Plexiglas buffer.

Figure 8 illustrates a comparison of pressure contour plots for the 38-mm mild-steel buffer and the 51-mm RHA buffer. With the RHA buffer, a more definite cracking response can be seen in the acceptor casing on the side near the buffer, but otherwise the results appear similar. A comparison of the pressure and impulse history plots of the RHA and mild-steel buffers, as shown in Figure 9, reveals no significant differences except that the pressures are somewhat higher and the ultimate impulse is significantly higher with the mild-steel buffer.

Figure 10 shows a comparison of pressure contour plots between a 38-mm RHA buffer and a 38-mm mild-steel buffer. With the buffer thicknesses equal, the RHA shows greater resistance to deformation and cracks clearly at late times. The pressure and impulse history plots are similar, as shown in Figure 11. The initial peak pressure is slightly higher and the ultimate impulse is somewhat lower with the RHA buffer.

The pressure and impulse results at the experimental threshold are summarized in Table 2. The impulse at the end of the first pulse, as well as the ultimate impulse (defined as the value at 250 μs) is included. As shown in the table, the peak pressure is the same for Plexiglas and RHA, but higher for mild steel. The first-pulse impulse is different for all three buffer materials. The ultimate impulse values are similar for Plexiglas and mild steel, but lower for RHA.

5. COMPARISON OF CTH AND STEALTH COMPUTATIONS

CTH computations were performed to compare with the results obtained in a previous sympathetic detonation study, which used the nonreactive Lagrangian code STEALTH (Starkenberg et al. 1987). In the STEALTH study, ramp waves as long as 25 μs were observed in the acceptor explosive when layered buffers were used between munitions. In one case, the layered buffers consisted of 10 mm of Plexiglas sandwiched between two 10-mm layers of steel. Figures 12 and 13 show pressure waveforms produced in the acceptor munition in STEALTH and CTH simulations of the same configuration. The results obtained with CTH show more structure in the ramp wave and shorter rise-times than those obtained with STEALTH.

6. HVRB PREDICTIONS OF SYMPATHETIC DETONATION

The HVRB explosive initiation model (Kerley 1992) was exercised in two series of CTH simulations. In one series, the donor and acceptor were in direct contact with the buffer. In the other, the donor and acceptor were separated by a fixed 12.7-mm space, and the buffer was centered in that space. In both series, the acceptors were filled with reactive Composition B, and buffer thicknesses were decreased until sympathetic detonation occurred.

Figure 14 shows a sequence of pressure and reaction variable contour plots for unbuffered projectiles separated by a 12.7-mm space. Pressure contours are shown on the right side, and reaction variable contours are shown on the left side of each plot. In this case, initiation of the acceptor occurs as the incident shock wave propagates through it.

A sequence of contour plots for a 6.4-mm-thick steel buffer in direct contact with the donor and acceptor munitions is shown in Figure 15. This illustrates a configuration that does not produce sympathetic detonation.

Figure 16 shows a sequence of pressure and reaction variable contour plots for a 6.4-mm Plexiglas buffer centered in a 12.7-mm space. Initiation of the acceptor occurs after reflection of the shock wave at 55 μs.

The results obtained in the HVRB simulations are summarized in Tables 3 and 4. In all cases, the buffer thicknesses required to prevent sympathetic detonation are less than those required in the experiments.

7. SUMMARY AND CONCLUSIONS

We simulated sypathetic detonation experiments with buffers at the threshold thickness. No propagation criterion associated with pressure-loading was revealed by the results of this study.

Buffers may prevent sympathetic detonation by influencing other aspects of the loading in addition to pressure. We observed that low-impedance Plexiglas buffers tend to spread out the pressure-loading over a longer period of time, while the high-strength steel and RHA buffers reduce deformation and damage.

When layered buffers are used, the results obtained with CTH show more structure in the ramp wave and shorter rise-times than those previously obtained with STEALTH. The response of explosives to ramp waves is not well understood, but it has been observed to be less violent than to a shock wave of the same strength.

Simulations with the HVRB explosive initiation model show that shock initiation may occur during propagation of the incident shock wave through the acceptor or after its reflection from the casing at the back of the acceptor. Buffers required to prevent sympathetic detonation in the computations were much thinner than those required in the experiments. This is another indication that mechanisms in addition to shock initiation contribute to sympathetic detonation. These results contrast sharply with those obtained in an earlier study using the Forest Fire initiation model and the 2DE code (Starkenberg, Huang, and Arbuckle 1984). In that study, no buffer that could prevent sympathetic detonation of Composite B-filled 105-mm projectiles was found.

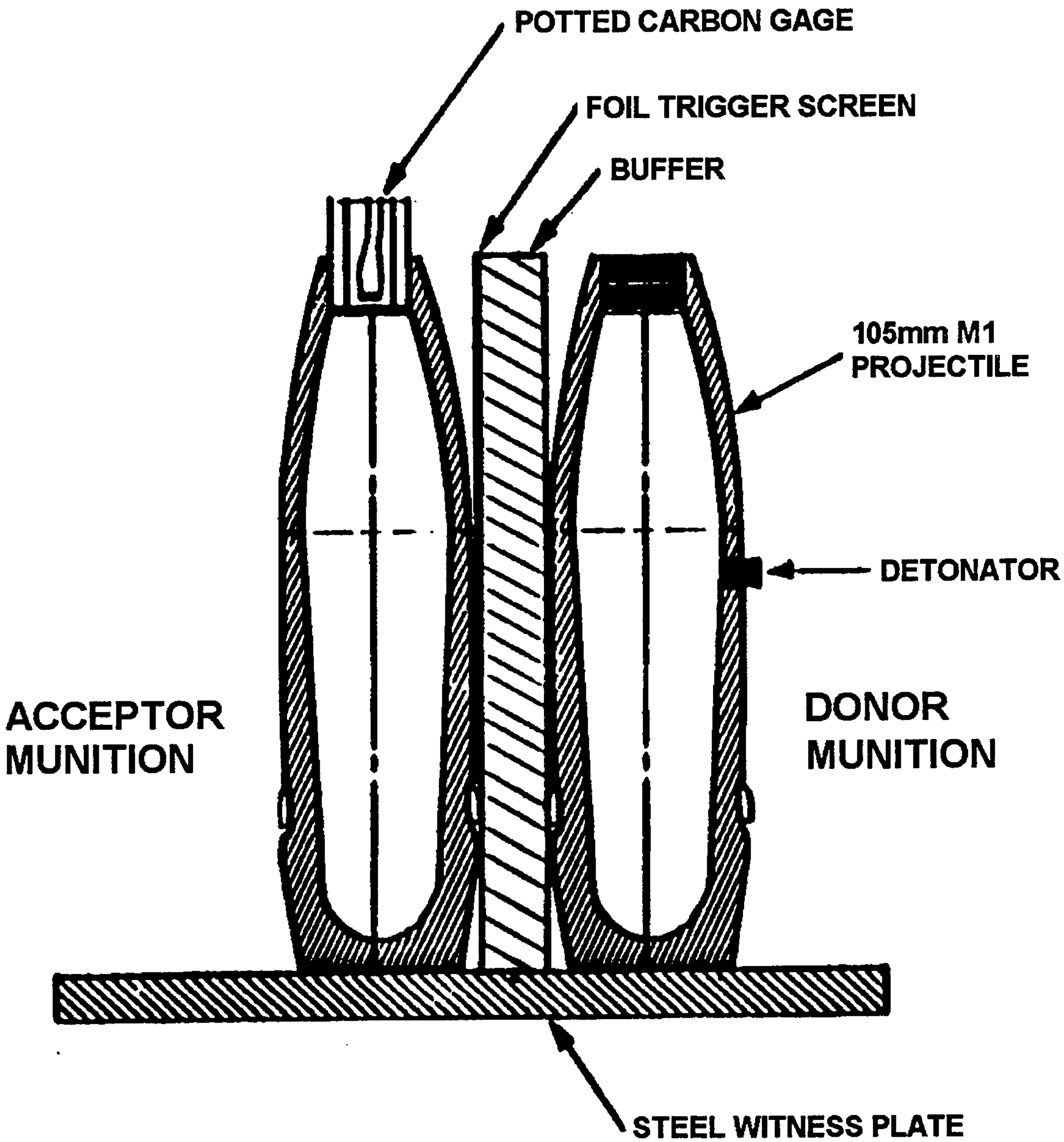


Figure 1. Experimental arrangement used by Boyle.

Table 1. Experimental Results

MATERIAL	THICKNESS (mm)	RESULT
MILD STEEL	<38	4 GOs
	38	NOGO
	38	NOGO
	>38	3 NOGOs
RHA	<51	2 GOs
	51	GO
	51	NOGO
	>51	3 NOGOs
POLYETHYLENE	<70	5 GOs
	70	GO
	70	NOGO
	76	GO
	76	NOGO
	76	NOGO
	>76	3 NOGOs

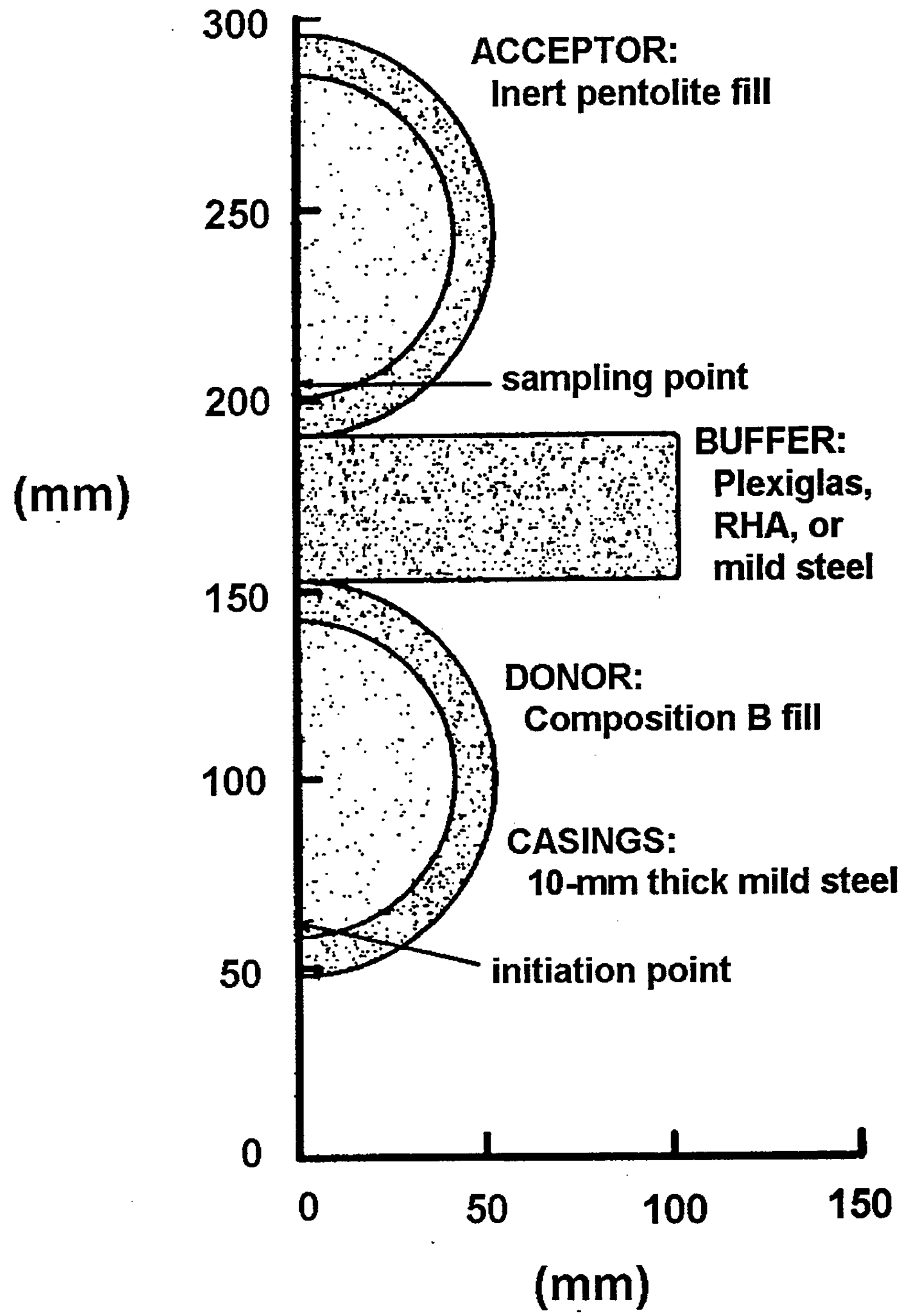


Figure 2. 2-D CTH Simulation.

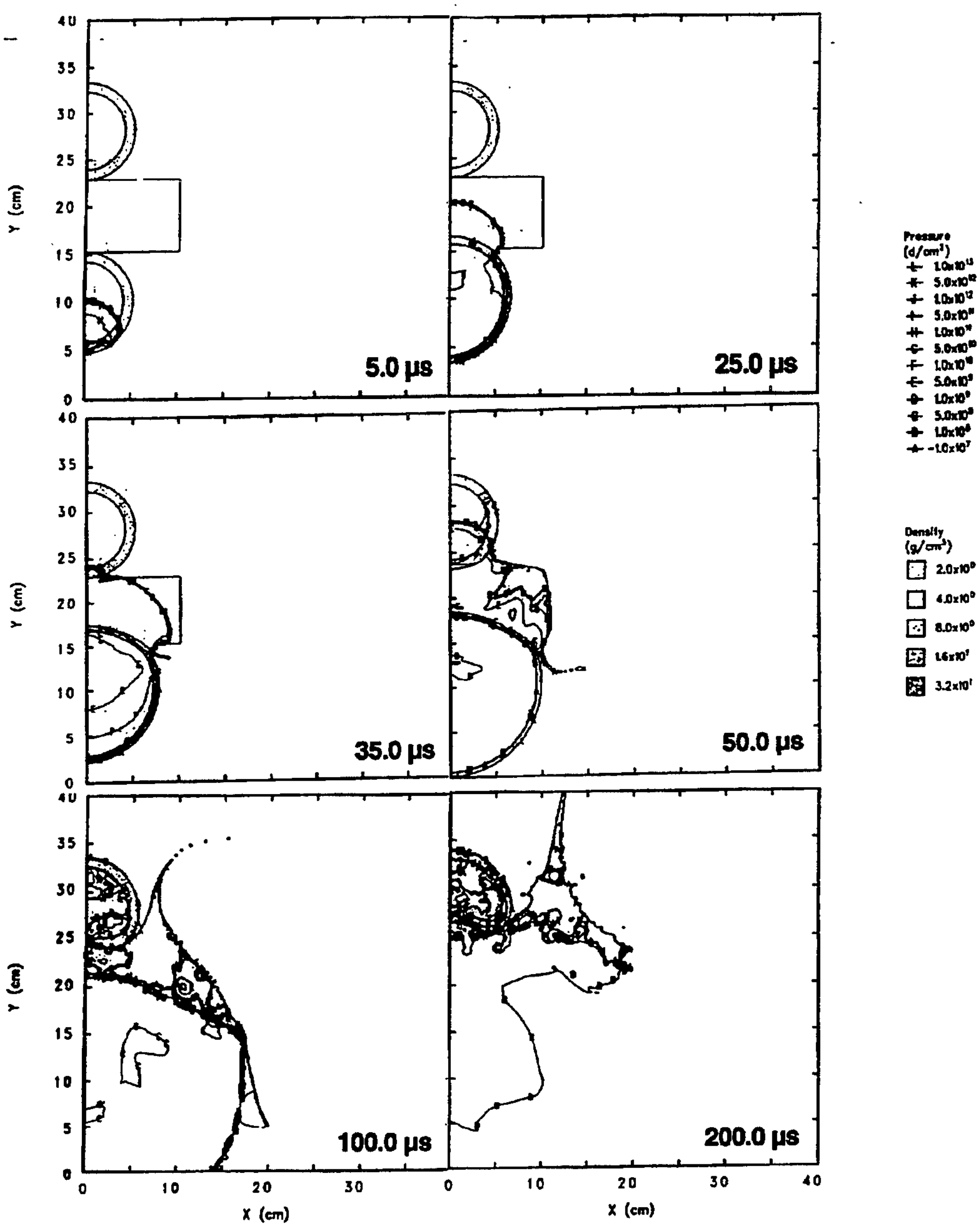


Figure 3. 76-mm Plexiglas buffer: contour plot sequence.

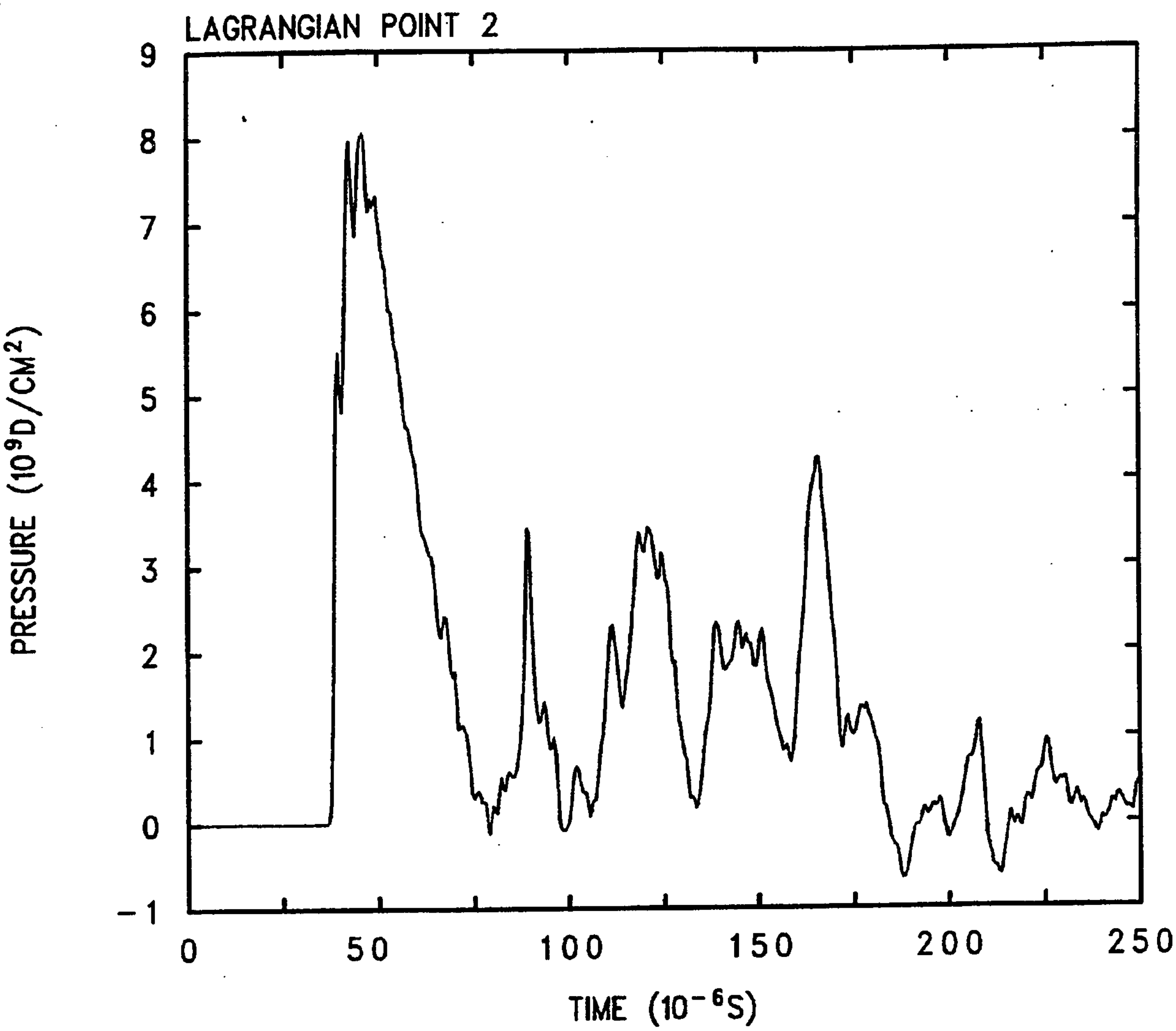


Figure 4. 76-mm Plexiglas buffer: pressure history.

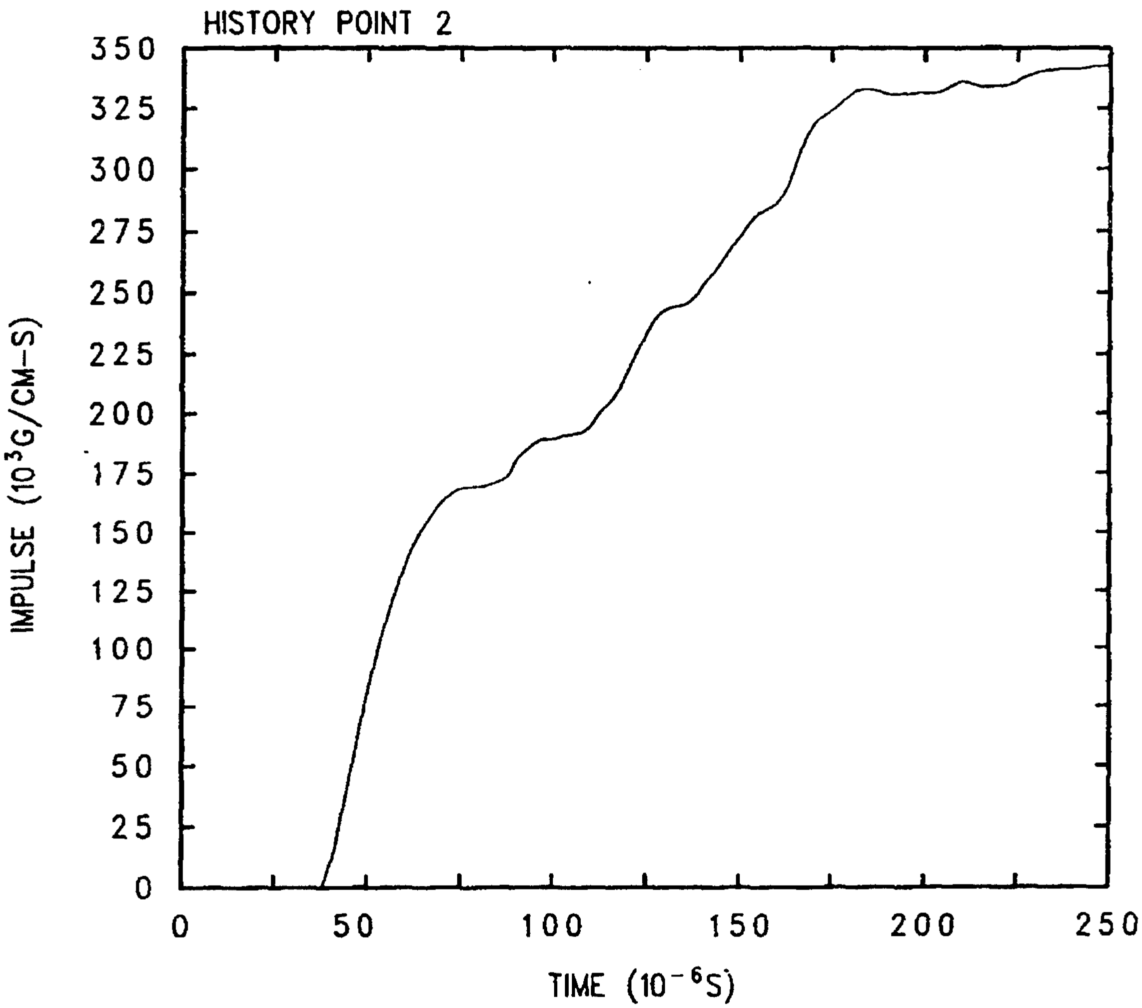


Figure 5. 76-mm Plexiglas buffer: impulse history.

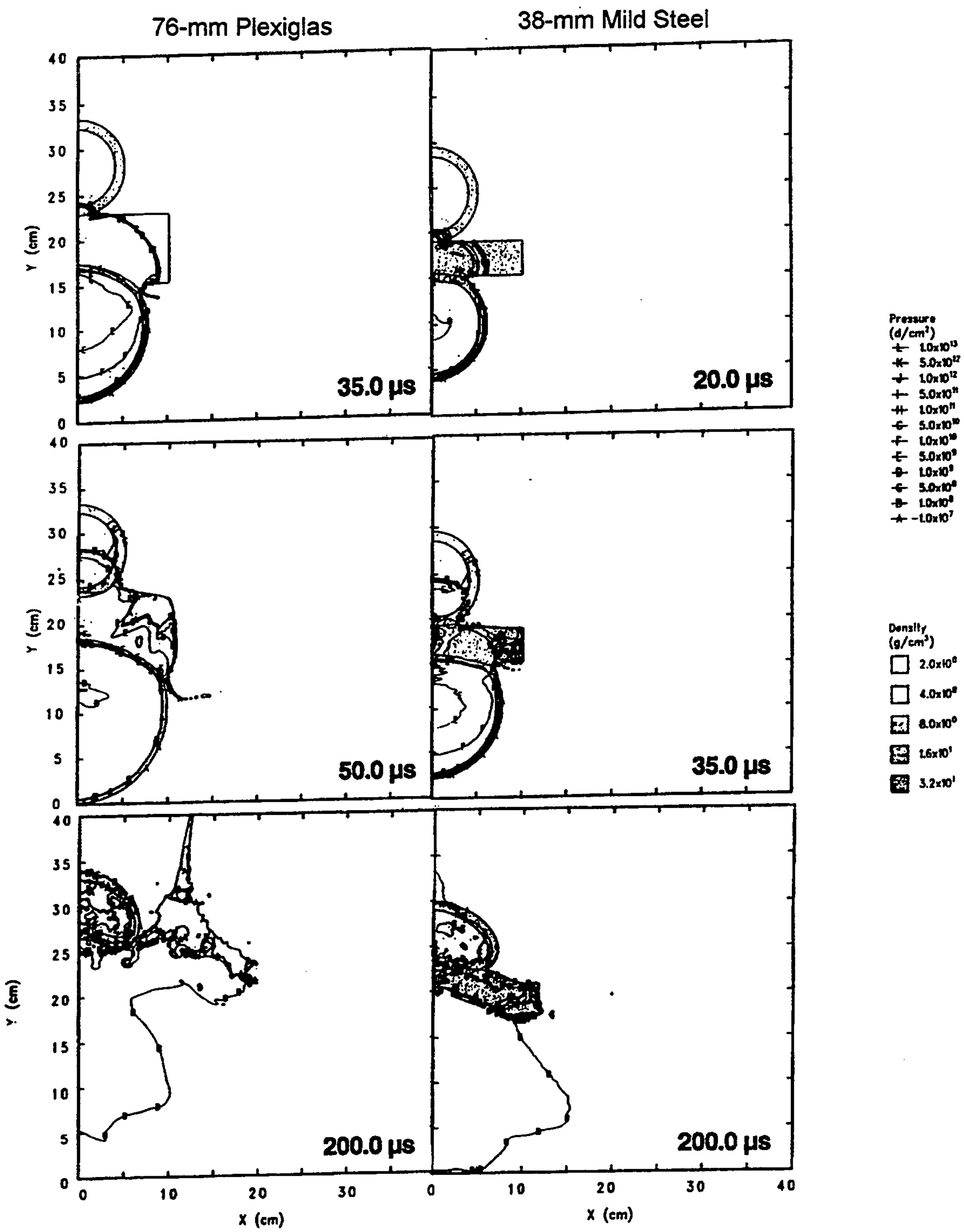


Figure 6. Plexiglas and mild steel: comparison of pressure contours.

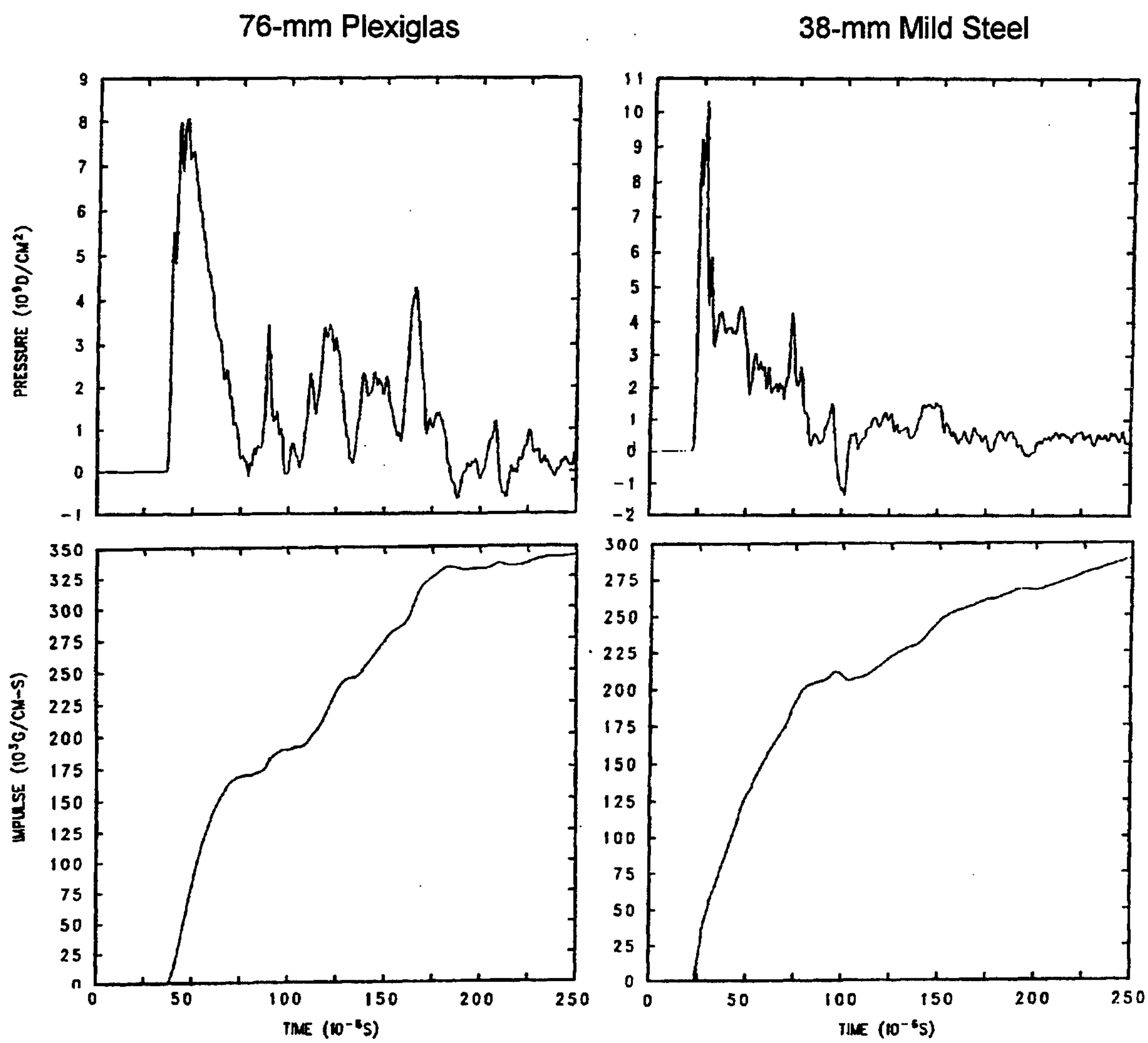


Figure 7. Plexiglas and mild steel: comparison of pressure and impulse histories.

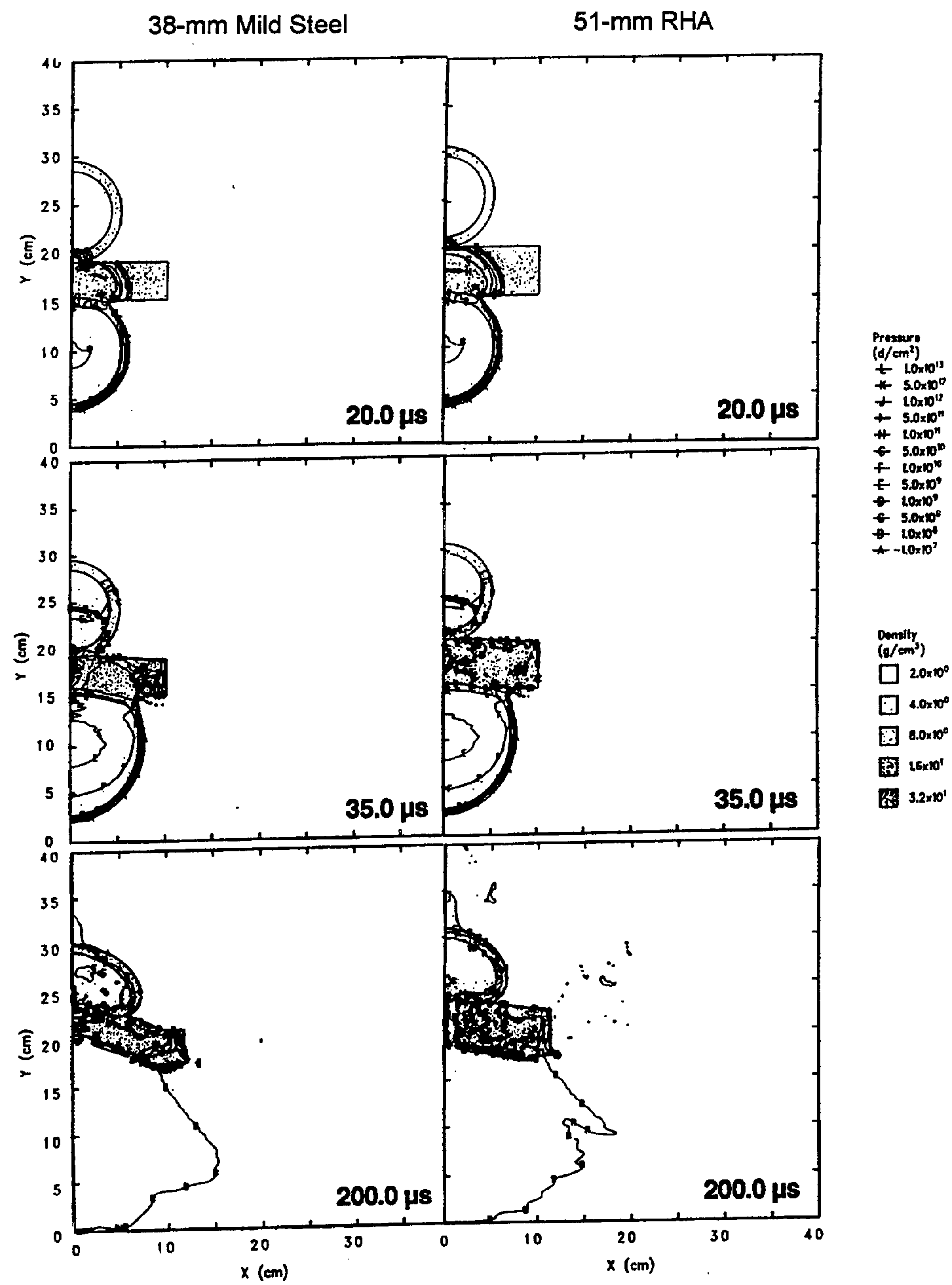


Figure 8. Mild steel and RHA: comparison of pressure contours at the experimental threshold.

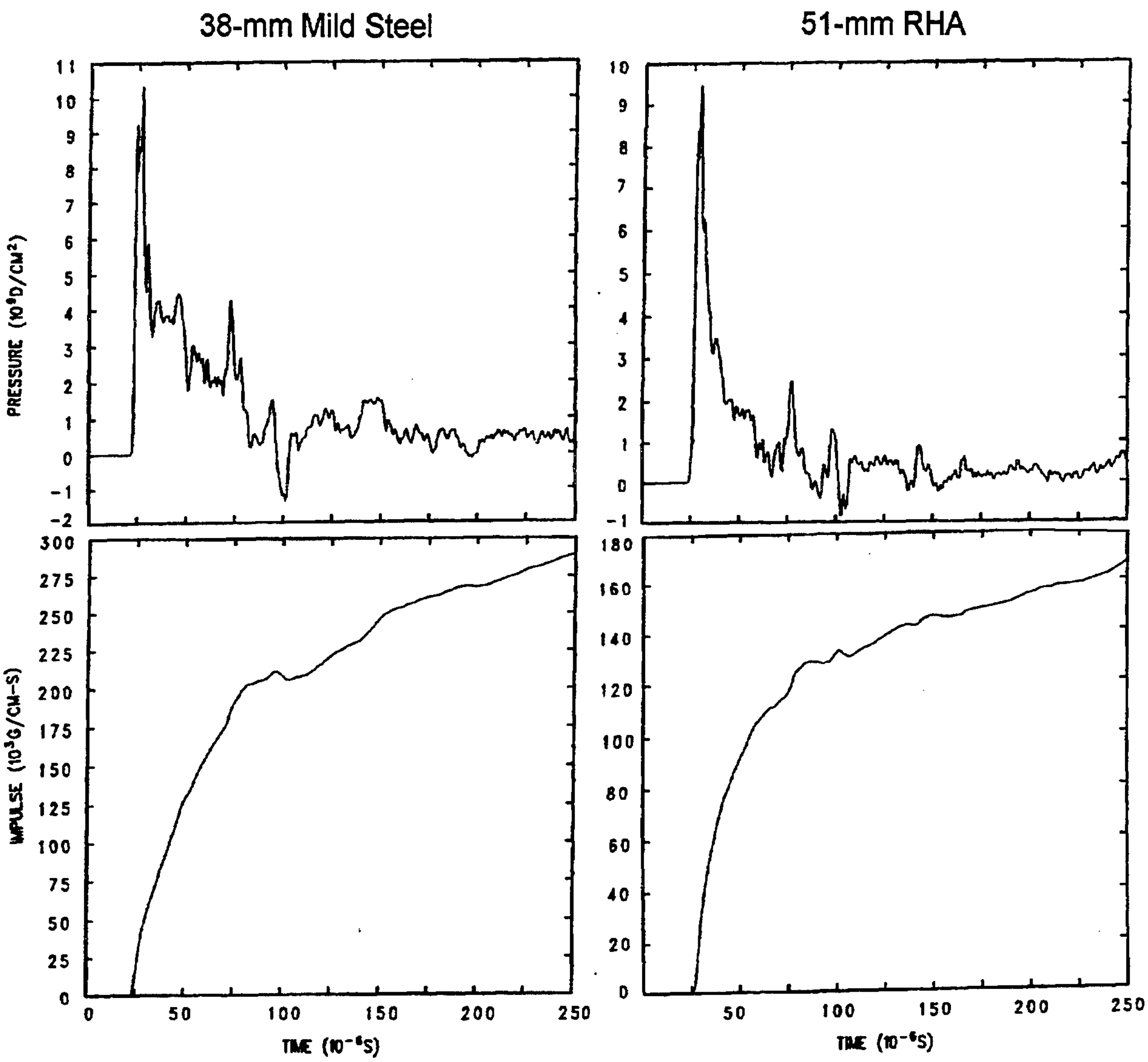


Figure 9. Mild steel and RHA: comparison of pressure and impulse histories at the experimental threshold.

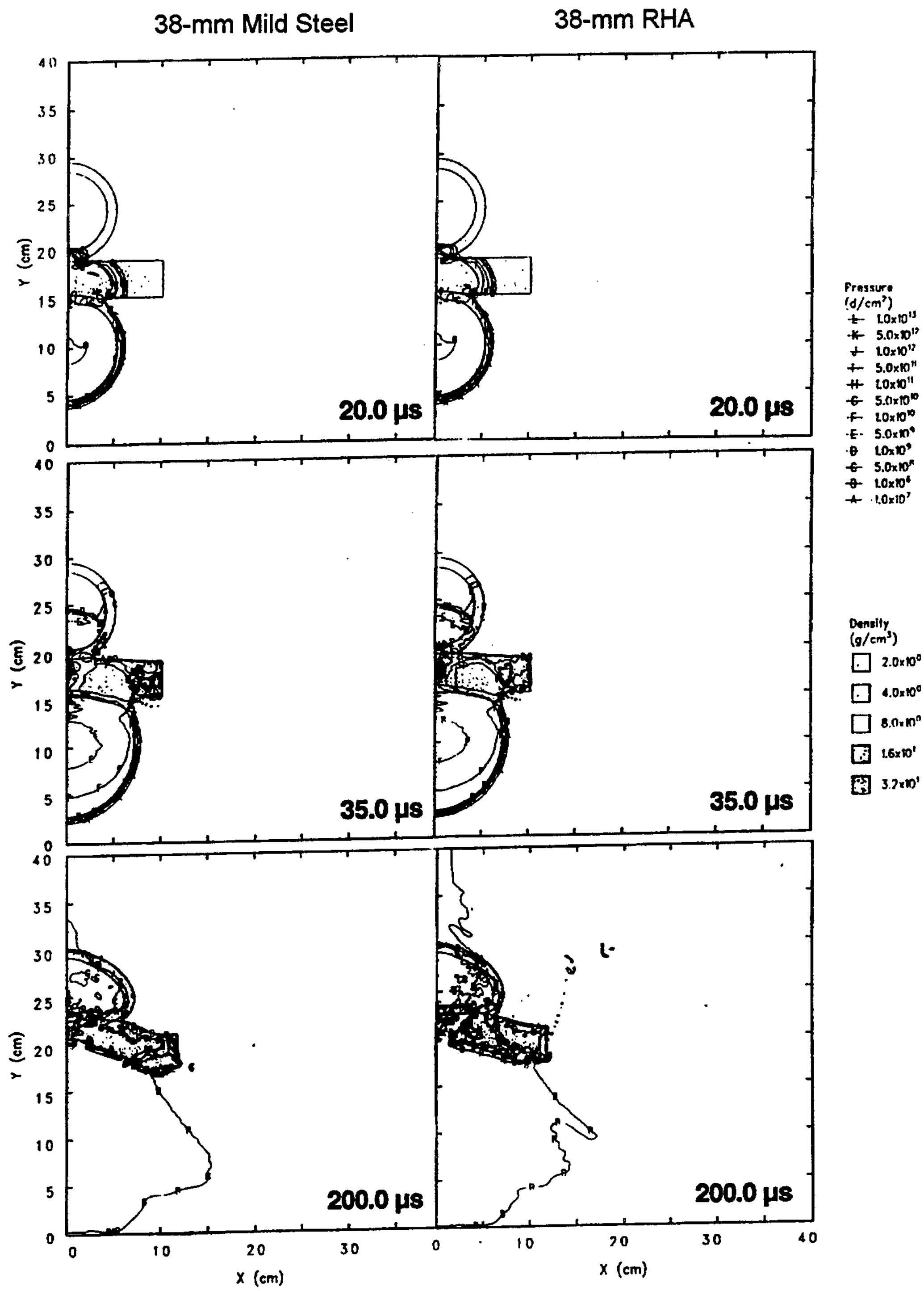


Figure 10. Mild steel and RHA: comparison of pressure contours at the same buffer thickness.

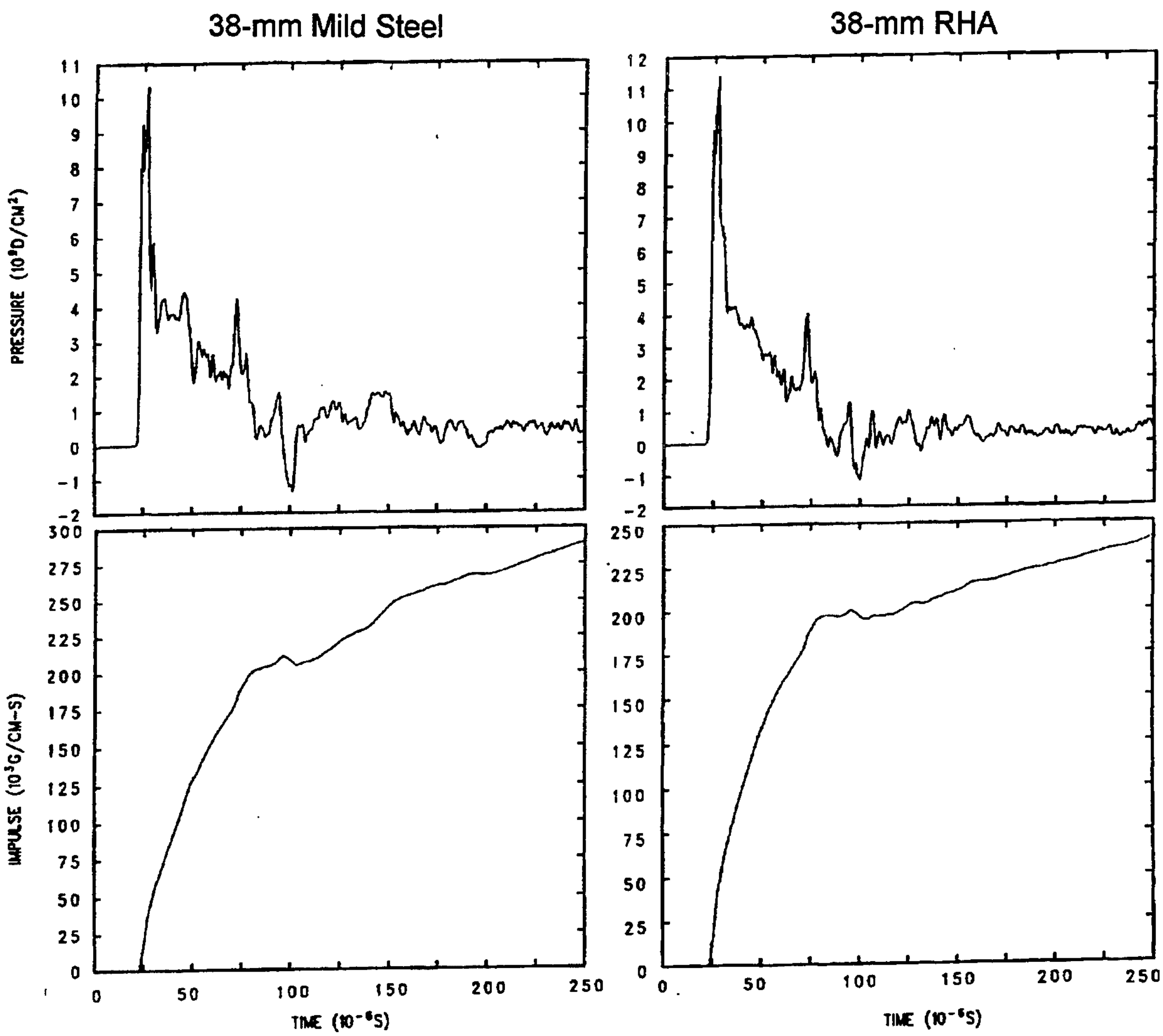
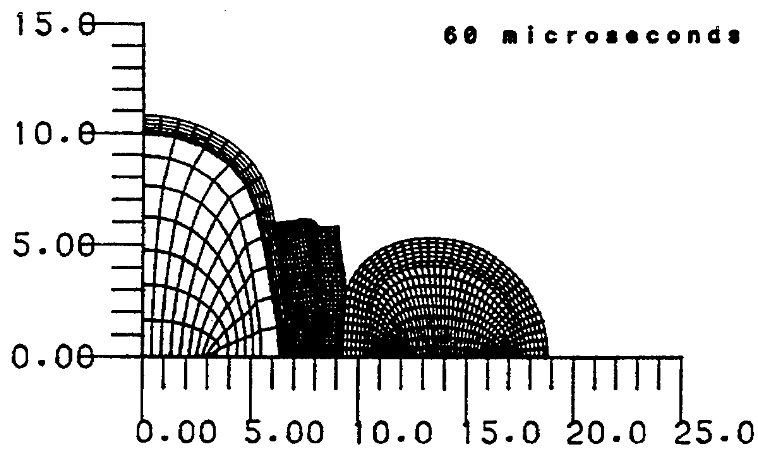


Figure 11. Mild steel and RHA: comparison of pressure and impulse histories at the same buffer thickness.

Table 2. Computed Pressure and Impulse at the Experimental Thresholds

BUFFER MATERIAL	BUFFER THICKNESS (mm)	PEAK PRESSURE (GPa)	FIRST-PULSE IMPULSE (kPa•s)	ULTIMATE IMPULSE (kPa•s)
PLEXIGLAS	70 76	0.94 0.81	17.6 16.9	36.0 34.2
MILD STEEL	32 38	1.22 1.28	24.7 20.3	35.1 28.8
RHA	51	0.94	12.9	16.8



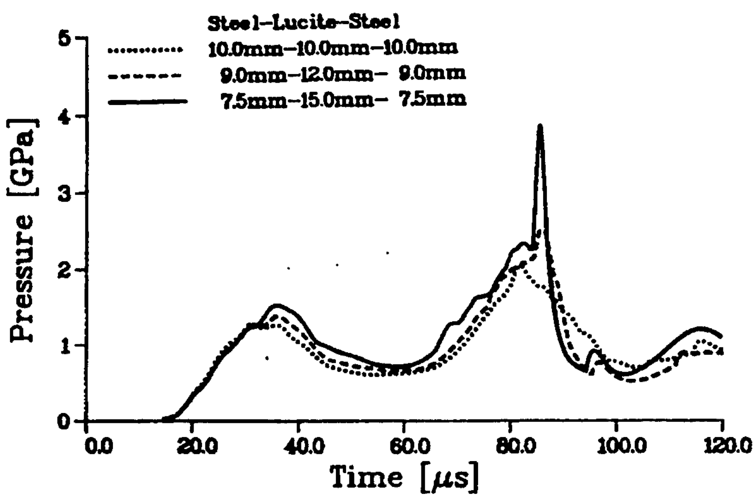


Figure 12. Results of the STEALTH sympathetic detonation simulation with layered buffers.

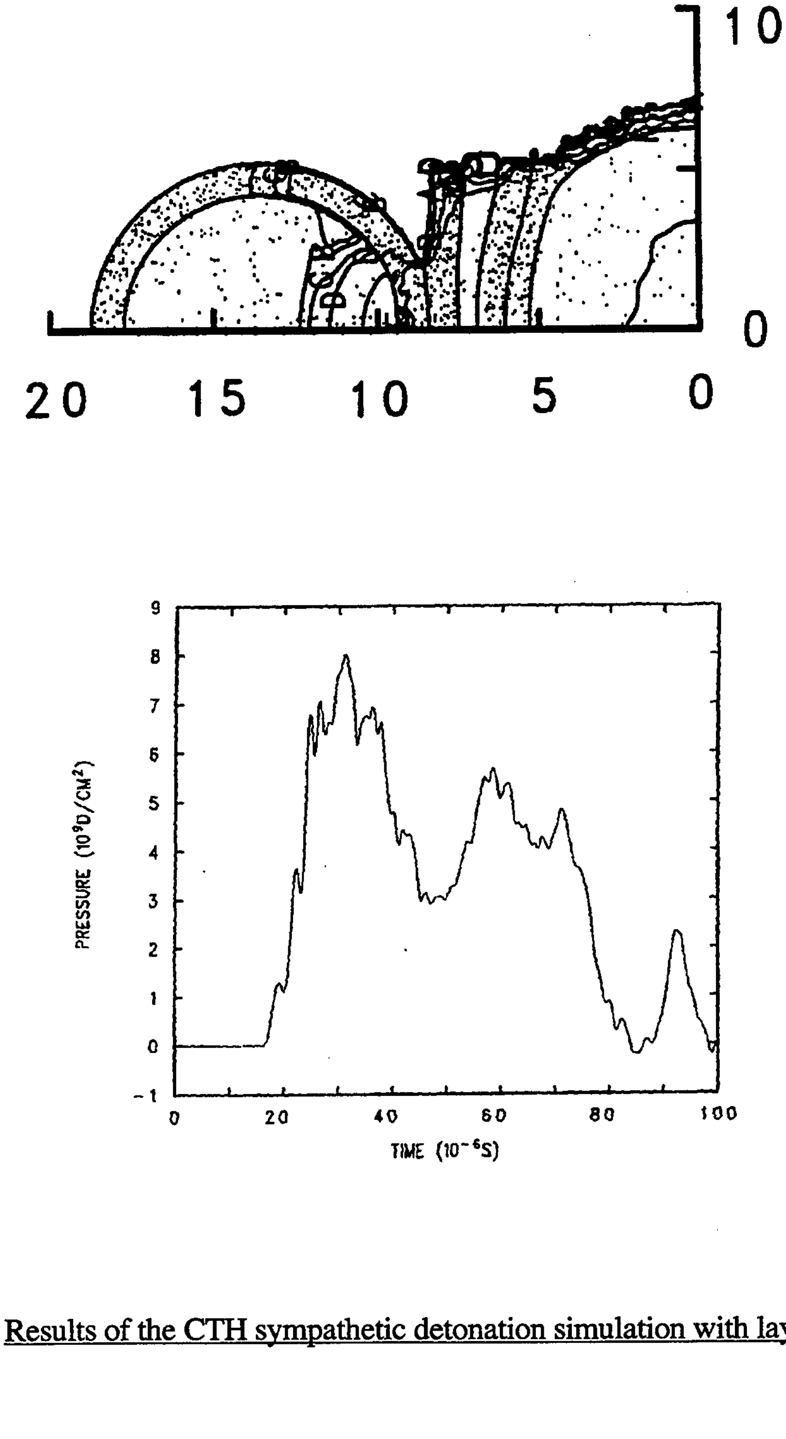


Figure 13. Results of the CTH sympathetic detonation simulation with layered buffers.

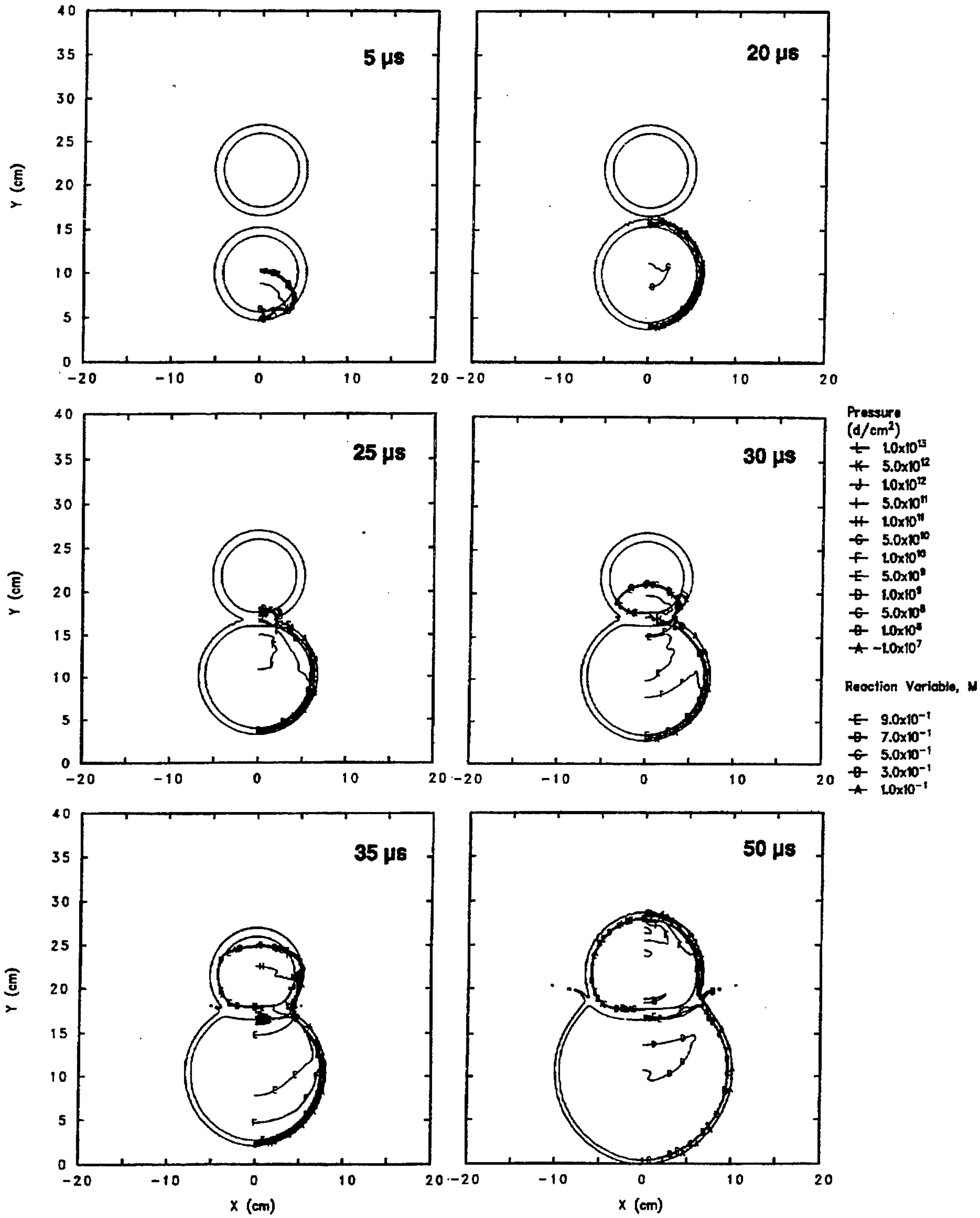


Figure 14. Unbuffered configuration with 12.7-mm separation: pressure and reaction variable contours.

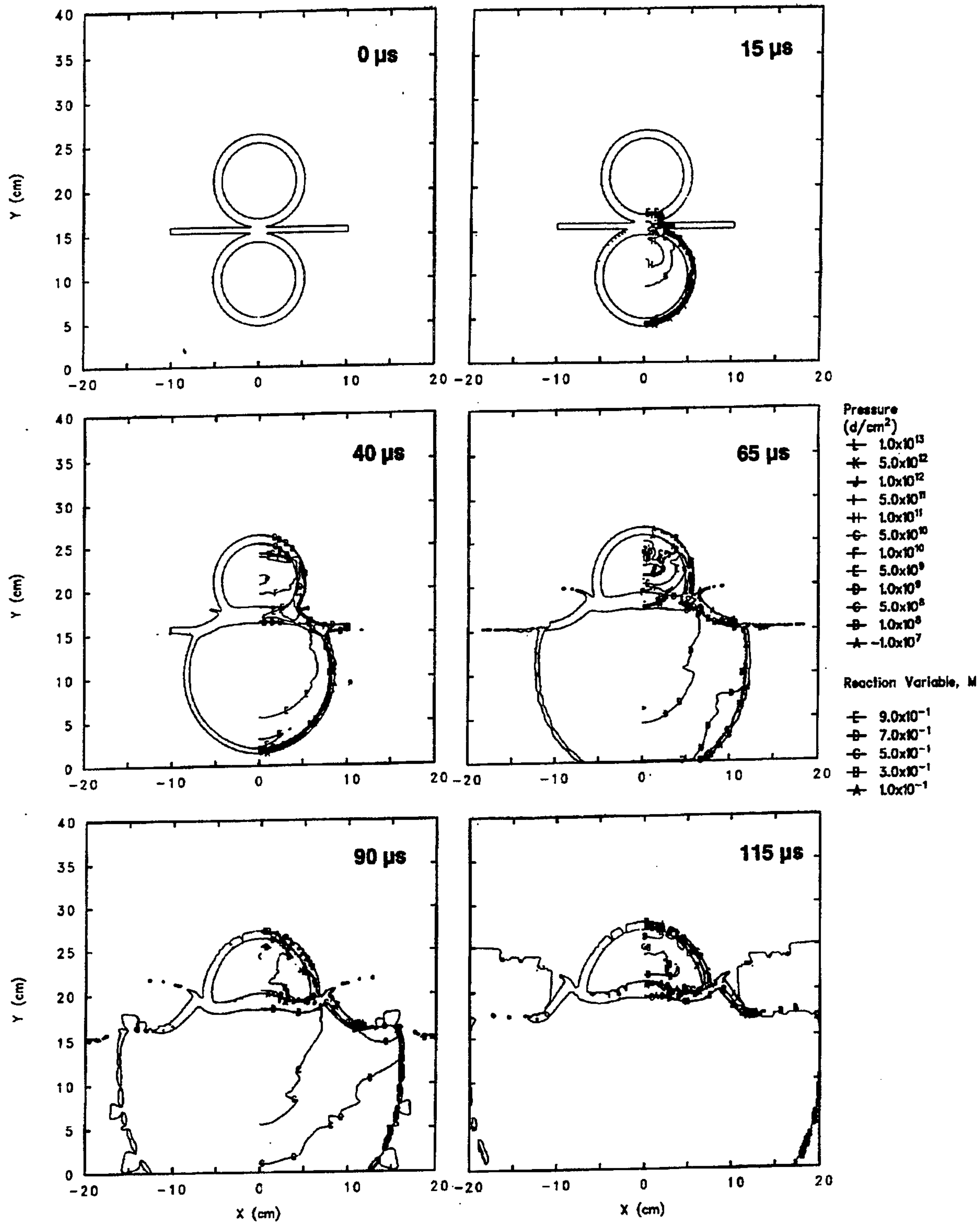


Figure 15. 6.4-mm Steel buffer in direct contact with donor and acceptor munitions: pressure and reaction variable contours.

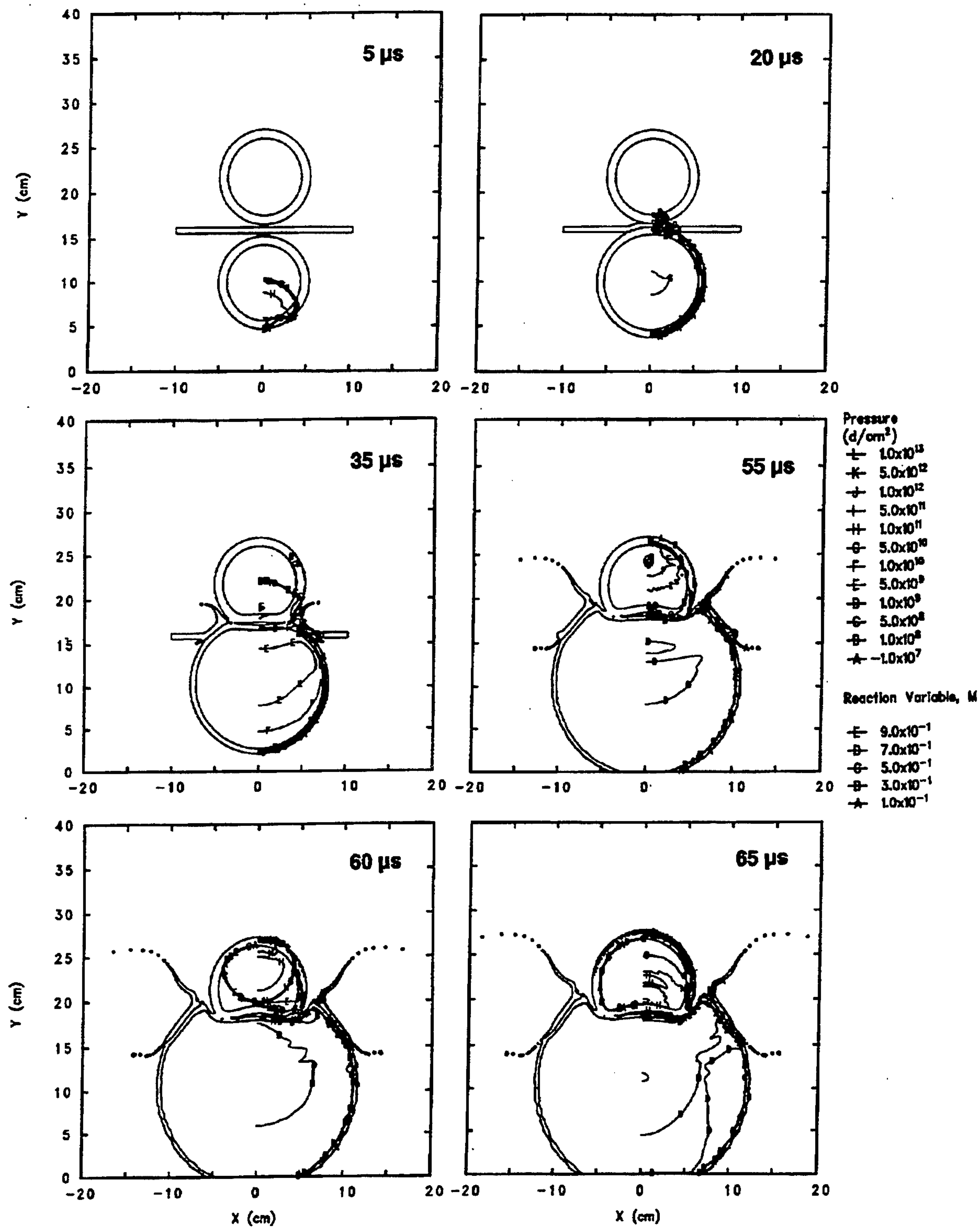


Figure 16. 6.4-mm Plexiglas buffer centered in 12.7-mm space: pressure and reaction variable contours.

Table 3. Sympathetic Detonation Predictions for the Contact Configurations

BUFFER THICKNESS (mm)	STEEL	PLEXIGLAS	AIR
3.2	GO (reflected wave, ~45μs)	GO (reflected wave, ~50μs)	
6.4	NOGO	NOGO	GO (incident wave, ~23μs)
12.7		NOGO	GO (incident wave, ~27μs)

Table 4. HVRB Results for 12.7-mm Munition-to-munition Separation Computations.

BUFFER THICKNESS (mm)	STEEL	PLEXIGLAS	AIR
1.6	GO (incident wave, ~30μs)	GO (incident wave, ~25μs)	
3.2	NOGO	GO (incident wave, ~25μs)	
6.4	NOGO	GO (reflected wave, ~55μs)	
12.7			GO (incident wave, ~27μs)

8. REFERENCES

Boyle, V. Personal Communication. U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, 1995.

Electric Power Research Institute. "STEALTH - A Lagrange Explicit Finite Difference Code for Solids, Structural, and Thermohydraulic Analysis." Palo Alto, CA. November 1981.

Hertel, E. S. , Jr., R. L. Bell, M. G. Elrick, A. V. Farnsworth, G. I. Kerley, J. M. McGlaun, S. V. Petney, S. A. Silling, P. A. Taylor, and L. Yarrington. "CTH: A Software Family for Multi-Dimensional Shock Physics Analysis." Proceedings of the 19th International Symposium on Shock Waves, Vol. 1, pp 377-382, July 1993.

Kerley, G. I. "CTH Equation of State Package: Porosity and Reactive Burn Models." Sandia Report SAND92-0553, April 1992.

Starkenberg, J., Y. K. Huang, and A. L. Arbuckle. "A Two-Dimensional Numerical Study of Detonation Propagation Between Munitions by Means of Shock Initiation." BRL-TR-02522, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD, September, 1983.

Starkenberg, J., T. M. Dorsey, K. J. Benjamin, A. L. Arbuckle. "A Computational Investigation of Shielding Effectiveness in Mitigating Stimuli Associated With the Sympathetic Detonation of Munitions." BRL-TR-2879, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD. December 1987.

INTENTIONALLY LEFT BLANK.

NO. OF COPIES	ORGANIZATION
2	DEFENSE TECHNICAL INFORMATION CENTER DTIC DDA 8725 JOHN J KINGMAN RD STE 0944 FT BELVOIR VA 22060-6218
1	HQDA DAMO FDQ DENNIS SCHMIDT 400 ARMY PENTAGON WASHINGTON DC 20310-0460
1	CECOM SP & TRRSTRL COMMCTN DIV AMSEL RD ST MC M H SOICHER FT MONMOUTH NJ 07703-5203
1	PRIN DPTY FOR TCHNLGY HQ US ARMY MATCOM AMCDCG T M FISETTE 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001
1	PRIN DPTY FOR ACQUSTN HQS US ARMY MATCOM AMCDCG A D ADAMS 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001
1	DPTY CG FOR RDE HQS US ARMY MATCOM AMCRD BG BEAUCHAMP 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001
1	ASST DPTY CG FOR RDE HQS US ARMY MATCOM AMCRD COL S MANESS 5001 EISENHOWER AVE ALEXANDRIA VA 22333-0001

NO. OF COPIES	ORGANIZATION
1	DPTY ASSIST SCY FOR R&T SARD TT F MILTON THE PENTAGON RM 3E479 WASHINGTON DC 20310-0103
1	DPTY ASSIST SCY FOR R&T SARD TT D CHAIT THE PENTAGON WASHINGTON DC 20310-0103
1	DPTY ASSIST SCY FOR R&T SARD TT K KOMINOS THE PENTAGON WASHINGTON DC 20310-0103
1	DPTY ASSIST SCY FOR R&T SARD TT B REISMAN THE PENTAGON WASHINGTON DC 20310-0103
1	DPTY ASSIST SCY FOR R&T SARD TT T KILLION THE PENTAGON WASHINGTON DC 20310-0103
1	OSD OUSD(A&T)/ODDDR&E(R) J LUPO THE PENTAGON WASHINGTON DC 20301-7100
1	INST FOR ADVNCD TCHNLGY THE UNIV OF TEXAS AT AUSTIN PO BOX 202797 AUSTIN TX 78720-2797
1	DUSD SPACE 1E765 J G MCNEFF 3900 DEFENSE PENTAGON WASHINGTON DC 20301-3900
1	USAASA MOAS AI W PARRON 9325 GUNSTON RD STE N319 FT BELVOIR VA 22060-5582

NO. OF COPIES	ORGANIZATION
1	CECOM PM GPS COL S YOUNG FT MONMOUTH NJ 07703
1	GPS JOINT PROG OFC DIR COL J CLAY 2435 VELA WAY STE 1613 LOS ANGELES AFB CA 90245-5500
1	ELECTRONIC SYS DIV DIR CECOM RDEC J NIEMELA FT MONMOUTH NJ 07703
3	DARPA L STOTTS J PENNELLA B KASPAR 3701 N FAIRFAX DR ARLINGTON VA 22203-1714
1	SPCL ASST TO WING CMNDR 50SW/CCX CAPT P H BERNSTEIN 300 O'MALLEY AVE STE 20 FALCON AFB CO 80912-3020
1	USAF SMC/CED DMA/JPO M ISON 2435 VELA WAY STE 1613 LOS ANGELES AFB CA 90245-5500
1	US MILITARY ACADEMY MATH SCI CTR OF EXCELLENCE DEPT OF MATHEMATICAL SCI MDN A MAJ DON ENGEN THAYER HALL WEST POINT NY 10996-1786
1	DIRECTOR US ARMY RESEARCH LAB AMSRL CS AL TP 2800 POWDER MILL RD ADELPHI MD 20783-1145

NO. OF COPIES	ORGANIZATION
1	DIRECTOR US ARMY RESEARCH LAB AMSRL CS AL TA 2800 POWDER MILL RD ADELPHI MD 20783-1145
3	DIRECTOR US ARMY RESEARCH LAB AMSRL CI LL 2800 POWDER MILL RD ADELPHI MD 20783-1145
	ABERDEEN PROVING GROUND
2	DIR USARL AMSRL CI LP (305)

NO. OF COPIES	ORGANIZATION
1	DIR LANL ATTN PHILIP M HOWE PO BOX 1663 LOS ALAMOS NM 87545
1	DIR LANL ATTN WILLIAM C DAVIS 693 46TH STREET LOS ALAMOS NM 87545
1	DIR LLNL ATTN CRAIG M TARVER PO BOX 808 LIVERMORE CA 94550
1	DIR SANDIA NATIONAL LAB ATTN EUGENE S HERTEL PO BOX 5800 ALBUQUERQUE NM 87185-5800
3	CDR NVL SURFC WARFARE CTR ATTN RICHARD R BERNECKER KIBONG KIM HAROLD W SANDUSKY 10901 NEW HAMPSHIRE AVE SILVER SPRING MD 20903-5640
1	CDR NVL SURFC WARFARE CTR INDIAN HEAD DIV ATTN RUTH M DOHERTY CODE 9230D 101 STRAUSS AVE INDIAN HEAD MD 20640-5035
1	CDR US ARMY ARDEC ATTN BARRY D FISHBURN VLADIMIR M GOLD PICATINNY ARSENAL NJ 07806-5000
1	KERLEY PUBLISHING SERVICES ATTN GERALD I KERLEY PO BOX 13835 ALBUQUERQUE NM 87192-3835
1	DYNA EAST CORP ATTN PEI CHI CHOU 3201 ARCH STREET PHILADELPHIA PA 19104

NO. OF COPIES	ORGANIZATION
1	VANDERBILT UNIV ATTN ARTHUR M MELLOR BOX 1592 NASHVILLE TN 37235-1592
1	GRYTING ENERGETICS SCIENCE CO ATTN HAROLD J GRYTING 7126 SHADOW RUN SAN ANTONIO TX 78250-3483
1	DIR WRIGHT LAB ARMAMENT DIRECTORATE ATTN J GREGORY GLENN EGLIN AIR FORCE BASE FL 32542-5434
	<u>ABERDEEN PROVING GROUND</u>
8	DIR USARL ATTN AMSRL WM T, W MORRISON AMSRL WM TB, R FREY J WATSON V BOYLE W LAWRENCE S SCHRAML E MCDOUGAL T DORSEY

NO. OF COPIES	ORGANIZATION
2	AGENCY FOR DEFENSE DEV ATTN JAIMIN LEE SO YONG SONG YUSEONG PO BOX 35 (1-3-7) TAEJON 305-600 KOREA
2	FRENCH GERMAN RSRCH INST (ISL) ATTN HENRY P A MOULARD MICHEL M S SAMIRANT 5 RUE DE GENERAL CASSAGNOU SAINT LOUIS CEDEX 68301 FRANCE
1	DEFENCE RSRCH ESTAB VALCARTIER ATTN CONRAD BELANGER 2459 PIE XI BOULEVARD NORTH QUEBEC GOA 1R0 CANADA
1	DEFENCE RESEARCH AGENCY ATTN PETER J HASKINS FORT HALSTEAD SEVENOAKS KENT TN14 7BP ENGLAND

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
June 1997

3. REPORT TYPE AND DATES COVERED
Final, Oct 94-Sep 96

4. TITLE AND SUBTITLE
Simulating Sympathetic Detonation of 105-mm Artillery Projectiles With CTH

5. FUNDING NUMBERS
PR: 1L162618AH80

6. AUTHOR(S)
Kelly J. Benjamin and John Starkenberg

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
ATTN: AMSRL-WM-TB
Aberdeen Proving Ground, MD 21005-5066

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TR-1365

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)

10.SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The CTH code was used to simulate sympathetic detonation experiments conducted using 105-mm projectiles separated by buffers of Plexiglas, rolled homogeneous armor (RHA), and mild steel. Buffer thicknesses near the experimental sympathetic detonation threshold were simulated. No propagation criterion associated with pressure loading was revealed by the results of this study. CTH computations were also made to confirm the presence of finite rise-time or "ramp" waves in the acceptor explosive (previously observed in Lagrangian computations) with layered buffers of Plexiglas and steel. The CTH results show more structure in the ramp wave and shorter rise times than those previously obtained. The History Variable Reactive Burn (HVRB) explosive initiation model in the CTH code was exercised in simulations of similar configurations. These simulations showed that initiation may occur during propagation of the incident shock wave through the acceptor or after its reflection from the casing at the back of the acceptor. Predicted buffer thicknesses required to prevent sympathetic detonation are much less than those determined in the experiments, indicating that mechanisms in addition to shock initiation contribute to sympathetic detonation.

14. SUBJECT TERMS
explosives, munitions, sympathetic detonation

15. NUMBER OF PAGES
35

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18 298-102

INTENTIONALLY LEFT BLANK.

USER EVALUATION SHEET/CHANGE OF ADDRESS

This Laboratory undertakes a continuing effort to improve the quality of the reports it publishes. Your comments/answers to the items/questions below will aid us in our efforts.

1. ARL Report Number/Author ARL-TR-1365 (Benjamin) Date of Report June 1997

2. Date Report Received ______

3. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which the report will be used.) ______

4. Specifically, how is the report being used? (Information source, design data, procedure, source of ideas, etc.) ______

5. Has the information in this report led to any quantitative savings as far as man-hours or dollars saved, operating costs avoided, or efficiencies achieved, etc? If so, please elaborate. ______

6. General Comments. What do you think should be changed to improve future reports? (Indicate changes to organization, technical content, format, etc.) ______

CURRENT ADDRESS

Organization ______

Name ______ E-mail Name ______

Street or P.O. Box No. ______

City, State, Zip Code ______

7. If indicating a Change of Address or Address Correction, please provide the Current or Correct address above and the Old or Incorrect address below.

OLD ADDRESS

Organization ______

Name ______

Street or P.O. Box No. ______

City, State, Zip Code ______

(Remove this sheet, fold as indicated, tape closed, and mail.)

(DO NOT STAPLE)